Evaluating the effects of a superabsorbent polymer on drought stress in two conifer species

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Introduction

- Early seedling death from summer drought is a major threat to reforestation success.
- Superabsorbent polymer (SAP) root dips are commonly applied to bare root seedlings during reforestation to reduce root dessication. Evidence of benefits to seedlings is mixed[1].
- To improve SAP biodegradability, companies are developing new polymers with organic backbones, such as starch or cellulose[2].
- In-situ leaf physiology measurements indicate real-time drought stress. Fv/Fm indicates the efficiency of photosystem II[3]. Stomatal conductance (g_s) indicates the flow rate of water vapor and CO_2 across stomata[4].

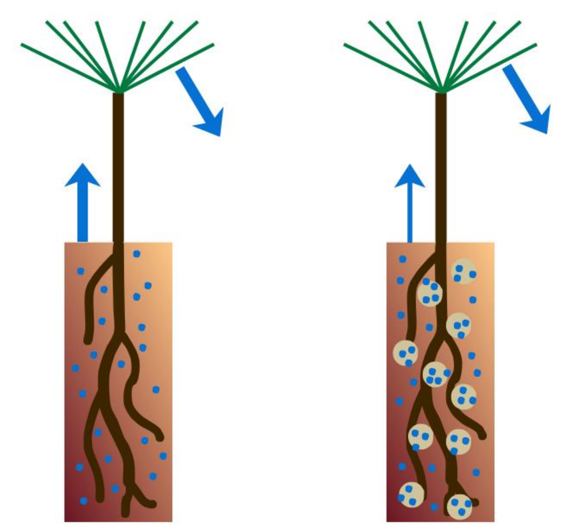


Figure (Top): Illustration of polymer (beige dots) effects on soil moisture (blue dots). Arrows represent evaporation and transpiration. (Bottom): Seedling root system with residual polymer after washing.

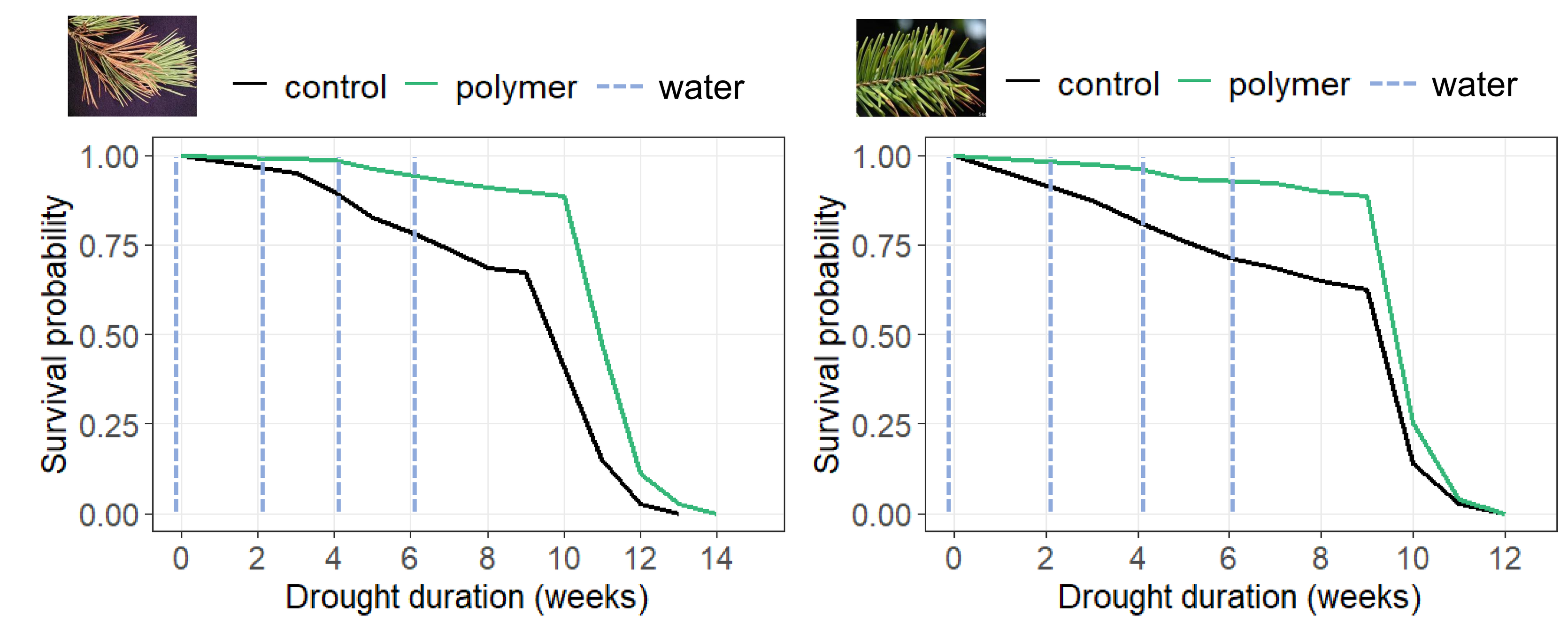
Research Goal: Assess the effects of a starch-based superabsorbent polymer on soil water retention and conifer seedling survival and physiology under summer drought stress.

Methods

- 320 bare root seedlings. 160 ponderosa pine, 160 douglas fir.
- 5g of dry Koasis™ polymer mixed into 2000 ml of sandy clay loam soil during greenhouse planting for 50% of seedlings in a complete randomized block design.
- 8 week drought treatment with biweekly rewatering. Seedlings watered weeks 0,2,4,6 after taking physiology measurements. After week 8, seedlings experienced severe drought with no rewatering.
- Measured survival (n=320), Fv/Fm (n=160), and stomatal conductance (n=160) weekly. Measured soil moisture (n=320) every 2-3 days for the first two weeks of drought.
- Survival data analyzed with Cox proportional hazards analysis.
- Physiology and soil moisture data analyzed with generalized additive mixed modeling.

Figure: Ponderosa pine seedling in greenhouse bin.

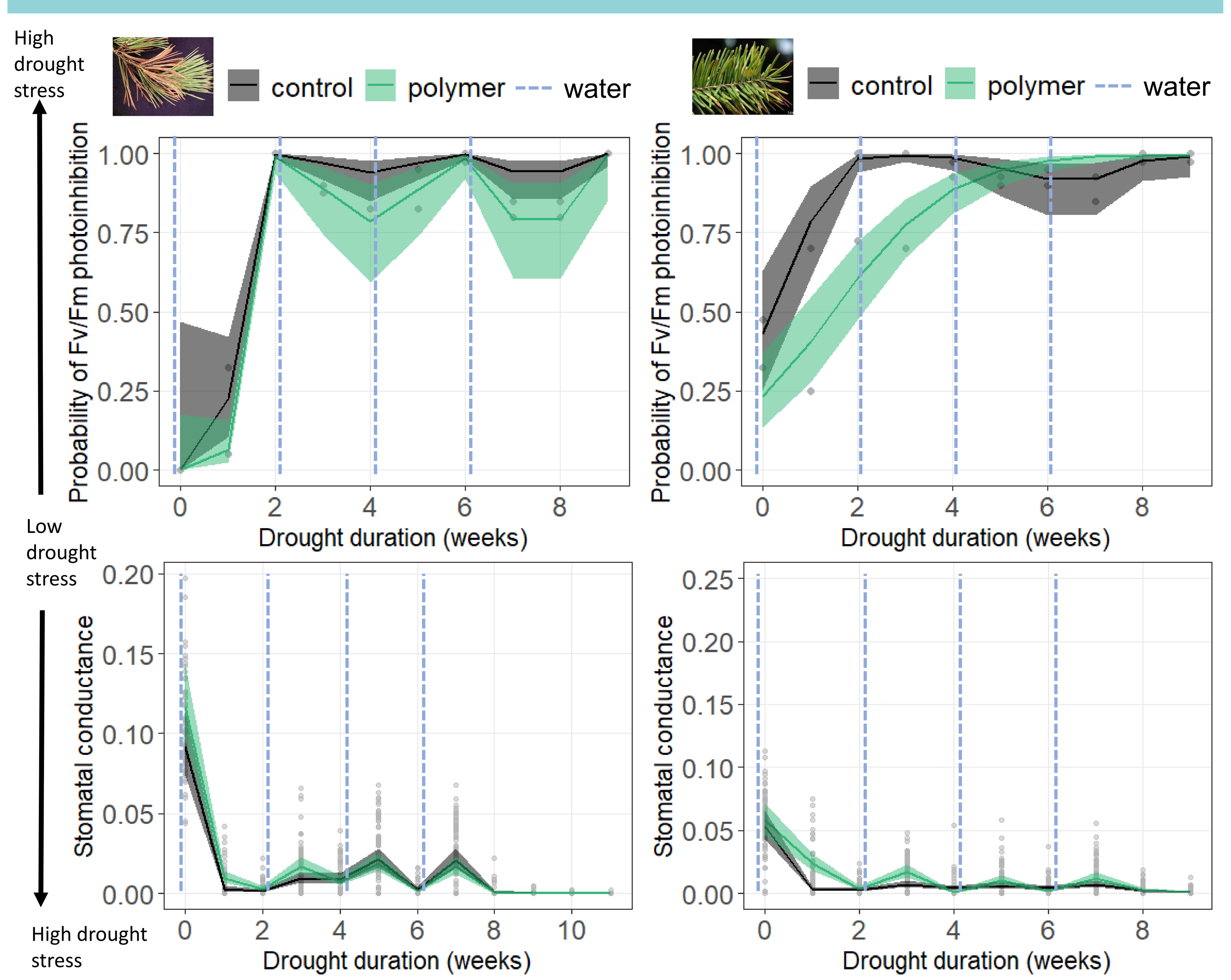
Survival Results



Polymer treatment extended survival

- Pines: polymer significant, mean time to death extended by 1.74 weeks
- Firs: polymer significant, mean time to death extended by 1.52 weeks

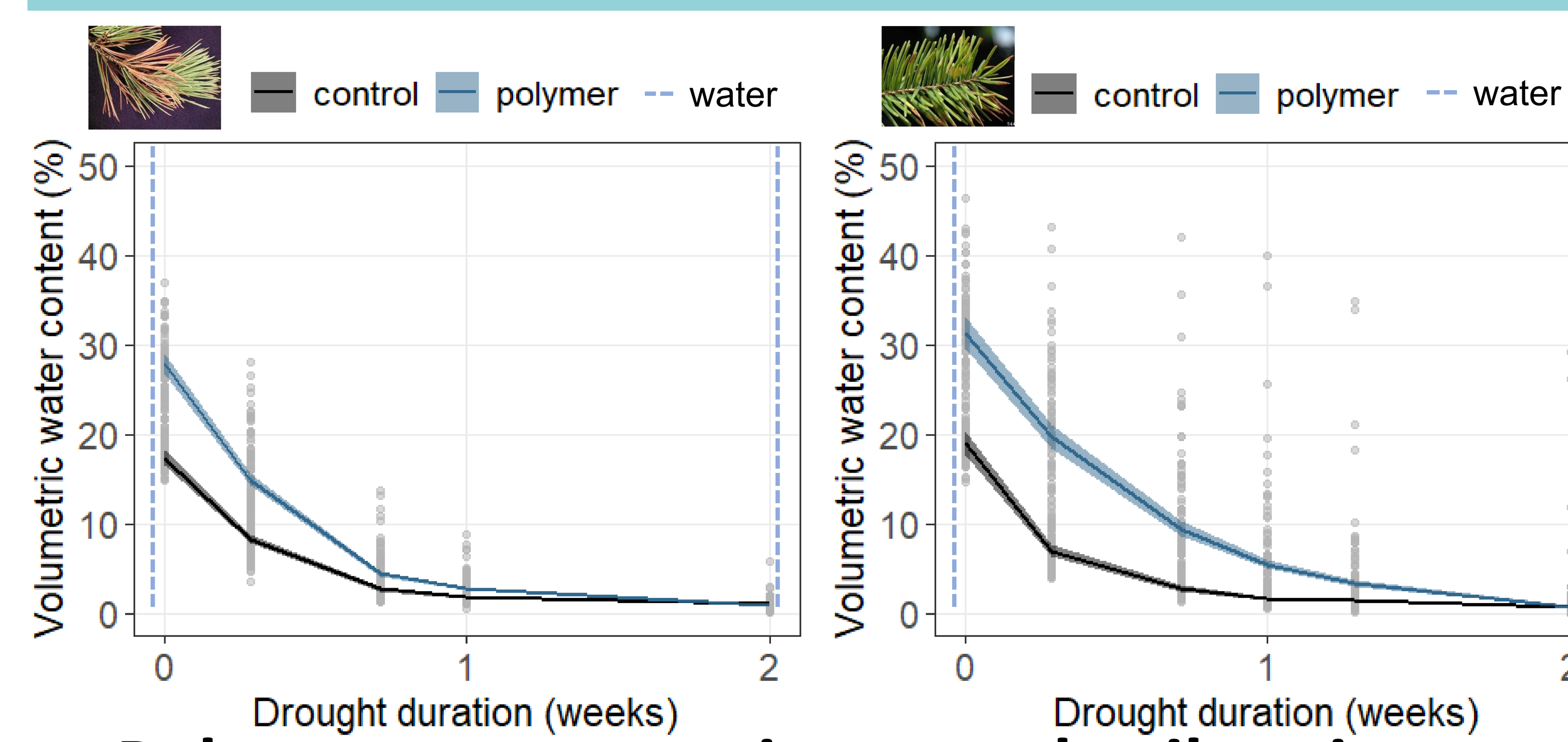
Physiology Results



Polymer treatment reduced photoinhibition and increased stomatal conductance (g_s)

- Photoinhibition defined as Fv/Fm < 0.81[5]
- Pines: polymer weakly significant, reduced probability of photoinhibition by 27.5% and increased average g_s by 0.007 in week 1 of drought.
- Firs: polymer significant, reduced probability of photoinhibition by 45% and increased average g_s by 0.021 in week 1 of drought.

Soil Moisture Results



Polymer treatment increased soil moisture

- Pines: polymer significant, field capacity increased by 9.34%
- Firs: polymer significant, field capacity increased by 12.7%

Discussion

- The polymer increased the field capacity and water retention of sandy clay loam soil. In greenhouse pots, however, nearly all soil moisture was absorbed by seedlings within two weeks of watering, regardless of polymer presence.
- The polymer improved seedling physiology parameters, especially for douglas fir. These effects mainly occurred during the first two weeks of drought stress, and treatment differences were minimal after repeated rewatering.
- Polymer benefits to soil moisture and physiology in the first few weeks of drought may be sufficient to improve survival throughout the summer drought period.
- Overall, the polymer showed potential to improve seedling survival in reforestation projects and should be further tested in a field setting.

References

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